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Continuous-Energy Version of the SCALE Control Modules for Use with Continuous-Energy KENO V.a and KENO-VI

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INTRODUCTION

KENO V.a and KENO-VI are multigroup Monte Carlo eigenvalue computer codes in the SCALE (Standardized Computer Analyses for Licensing Evaluation) Code package[1] that are used throughout the world to facilitate the safe handling and use of fissile material. At Oak Ridge National Laboratory (ORNL), continuous-energy versions of KENO V.a and KENO-VI have been developed, which remove the limitations inherent in the multigroup versions of these codes.[2] Previous publications have focused on the development and testing of a stand-alone pointwise version of KENO V.a.[2-4] The focus of this work is the development and testing of new versions of the CSAS and CSAS6 control modules in SCALE that read the user input and create the appropriate KENO input file and link the required libraries. A stand-alone KENO problem requires a mixing table that contains the nuclides and their atom densities for each mixture. New control modules, based on the SCALE 5 CSAS and CSAS6 control modules, have been developed for use with continuous-energy KENO V.a and continuous-energy KENO-VI that use the same input as the SCALE 5 version of the control modules.

CODE DEVELOPMENT

Continuous-energy versions of KENO V.a and KENO-VI, as well as a preliminary continuous-energy library containing 50 nuclides/isotopes at one temperature, have been developed and tested at ORNL. In order to fully utilize these continuous-energy versions of KENO V.a and KENO-VI, continuous-energy versions of CSAS and CSAS6 are required to read the SCALE standard composition input and create the appropriate KENO input. The multigroup CSAS modules perform multiple functions:

1. create a master library,
2. convert standard composition input to nuclide/isotope and atom densities,
3. set-up the KENO and resonance processing code inputs,
4. control the sequence in which the functional modules are called.

The continuous-energy versions of CSAS and CSAS6 are required only to:

1. read the standard composition input,
2. create the appropriate KENO input,
3. link the individual point nuclide data and create a continuous-energy library,
4. call the appropriate version of KENO.

No resonance processing is required, which removes the need for unit cell data and the resonance processing codes such as BONAMI, NITAWL, or CENTRM/PMC.

VERIFICATION

The CSAS and CSAS6 sample problems were modified so that the same problems could be run in both the SCALE 5 multigroup and continuous-energy versions of the codes. The most significant modification was changing the CSAS4 search cases to CSAS25 cases. This was necessary because continuous-energy CSAS currently does not contain a search option. Also, several materials were replaced, such as Zr with Al, because the point library currently contains only 50 nuclides. Finally, homogenized cell mixtures were removed because this option is not available in the pointwise versions.

The SCALE 5 version of the sample problems used multigroup cross sections derived from ENDF/B-V data, where the continuous-energy version of the sample problems used continuous-energy cross sections derived from ENDF/B-VI data. The modified CSAS and CSAS6 sample problems were processed using both the SCALE 5 multigroup and continuous-energy versions of the codes. Table I contains a brief description of each problem and the calculated results. In all instances the calculated k_{eff} values agreed within 4σ, with the majority of the problems agreeing to within 2σ.

CONCLUSIONS

The continuous-energy CSAS and CSAS6 control modules allow SCALE 5 multigroup CSAS and CSAS6 problems to be analyzed using continuous-energy KENO V.a and KENO-VI, respectively, with minimum changes to the inputs. Like their SCALE 5 multigroup counterparts, these new control modules significantly simplify the input requirements and reduce the user effort to set up and run problems. The results show that the continuous-energy CSAS and CSAS6 problems produce similar results to the multigroup versions

Significant work remains on the continuous-energy versions of these SCALE modules prior to releasing production versions. Several areas where future work

will be focused include speed up, memory requirements, and data. The current versions of continuous-energy KENO V.a and KENO-VI require at least an order of magnitude more CPU time than their group counterparts and require significantly more memory. The poor efficiency of the codes is due to the number of table searches required for processing collisions and the size of the tables. The memory requirement is due to the size of the continuous- energy libraries. All the kinematics is built into the cross-section libraries instead of the code. The continuous- energy cross-section data for each nuclide is stored in a separate file in a common directory. For a given problem a continuous-energy library is created, which contains the data for all the isotopes/nuclides in the problem at the specified temperatures. Currently, there are only 50 isotopes/nuclides, each at only one temperature, in the continuous-energy library directory. This library needs to be tested and debugged prior to creating a complete ENDF/B-VI library of all nuclides at multiple temperatures.

TABLE I. Comparison of CSAS/CSAS6 SCALE 5 and Pointwise Results.

Case	Description	SCALE 5 ENDF/B-V $k_{eff}(\pm\sigma)$	Pointwise ENDF/B-VI.7 $k_{eff}(\pm\sigma)$
1	CSAS – 4 Aqueous, 4 Metal Array	1.0030 (0.0025)	0.9986 (0.0021)
2	CSAS – PWR-Like Fuel Bundle in Poison Sheaths	0.7346 (0.0039)	0.7316 (0.0040)
3	CSAS – 4 Smeared fuel bundles in cask	0.7021 (0.0028)	0.6994 (0.0039)
4	CSAS – Bare 2C8 Array	0.9644 (0.0018)	0.9572 (0.0017)
5	CSAS – Uranyl Fluoride Solution Tank	1.0293 (0.0026)	1.0237 (0.0024)
6	CSAS – Hemispherical Uranyl Fluoride Solution Tank	0.9955 (0.0030)	0.9870 (0.0021)
7	CSAS – Flux Trap between Smeared Fuel Bundles	0.7013 (0.0015)	0.7034 (0.0016)
1	CSAS6 – Y-30 Critical Assembly	1.0061 (0.0019)	1.0030 (0.0019)
2	CSAS6 – Cross-89 Critical Assembly	1.0070 (0.0016)	1.0023 (0.0019)
3	CSAS6 – Bare 93.2 % Enriched Bare Uranium Sphere	1.0013 (0.0017)	0.9953 (0.0016)
4	CSAS6 – Bare 93.2 % Enriched Bare Uranium Hemisphere w/ Mirror Albedo	1.0008 (0.0018)	0.9936 (0.0020)
5	CSAS6 – Bare 93.2 % Enriched Bare Uranium ¼ Sphere w/ Mirror Albedo	0.9975 (0.0020)	0.9945 (0.0019)
6	CSAS6 – Bare 93.2 % Enriched Bare Uranium 1/8 Sphere w/ Mirror Albedo	0.9980 (0.0020)	0.9963 (0.0022)
7	CSAS6 – Grotesque	1.0016 (0.0019)	1.0008 (0.0020)

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